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Soil Treatments and the Growing of Locust Seedlings

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SOIL TREATMENTS AND THE GROWING OF LOCUST SEEDLINGS

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INTRODUCTION

The production of locust seedlings (*Robinia pseudoacacia*) in the nursery is subject to various hazards, the principal ones of which are the reduction in the initial stand by various soil-inhabiting fungi, insect and nematode damage, and the competition of weeds in the beds where the young plants are growing. Preliminary trials conducted at the Green Springs State Forest Nursery in 1956 indicated that certain chemicals could be used as preplant soil treatments to increase the percentage of seedling emergence and survival, and to reduce the number of weeds present in the plant beds (1).

A screening of soil samples taken at random over the nursery area in the spring of 1956, and at yearly intervals since, has shown that neither the root-knot nematode (*Meloidogyne hapla*) nor the lesion nematode (*Pratylenchus spp.*) were present in appreciable numbers in the plant beds. Neither were there any other plant parasitic nematode species present in sufficient numbers to interfere with the growth of the locust seedlings. Thus, in a program designed to improve the conditions under which young locust plants were being produced, a nematocide was included in the list of preplant soil treatments being tested in only a few instances.

Furthermore, since there was little previous history of serious insect damage to the locust seedlings, an insecticide was added in only a few instances. A listing of the various compounds used and their chemical composition is given in an appendix at the end of this bulletin.

However, a nematocide (ethylene dibromide) and an insecticide (dieldrin) were included in the preliminary preplant soil treatments applied in 1956 on the chance that they might play some part in improving seedling stand and survival of the young locust plants. Neither compound gave any worthwhile stand increase, but dieldrin did give some reduction in a mild form of root damage caused by the larvae of the June beetle (*Phyllophaga spp.*) The nematocide used in these

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treatments was somewhat injurious to the locust seedlings and brought about a final reduction in stand and some stunting of their growth.

The good results obtained with Vapam and Mylone, two compounds that break down in the soil to give the same end product (an isothiocyanate), and both of which possess fungicidal and herbicidal properties, suggested that further experimental work should be done with them, as well as possibly other soil fungicides, in an effort to develop a recommendation for future use in the growing of locust seedlings.

METHODS AND EQUIPMENT

Locust is usually seeded in Ohio nurseries sometime between June 10 and 25, at which time the soil where the plant beds are to be located is comparatively warm and usually near optimum moisture content.

The seeds are usually soaked in sulphuric acid to cut down and standardize the time necessary for germination to 4 to 15 days, since untreated seed may require from 12 to 65 days for seedling emergence. Planting is then delayed until at least mid-June to keep the seedlings from becoming too large before growth ceases in the fall. Even under these conditions it frequently becomes necessary in September to clip the seedlings to a height of about 15 inches to prevent them from becoming too tall. The seedlings are often subject to attack by various soil-inhabiting fungi that may kill varying percentages of the young plants, depending upon the number and kinds of fungi present and the weather conditions at the time. Also, the young seedlings frequently are forced to enter almost immediate competition with weeds. Thus, any effort to grow more and better plants should be directed toward the elimination of both fungi and weed seeds.

This was done in the various experiments reported here by treating the soil of the nursery beds to a depth of 3 to 8 inches with various chemical compounds about 10 to 14 days before planting. Since the materials used during the 6-year period over which the experimental work was conducted varied rather widely in their physical and chemical characteristics, it was necessary to devise and use several different types of application equipment (2). Most of the treatments were applied with a rotary tiller of the type shown in Figure 1. This tiller is 60 inches wide and will till completely the 4-foot wide beds used for planting locust, as well as most of the walk or depression which separates one bed from another. It is adjustable for depth and was used at depths of 3, 4, 6, and 8 inches.

All compounds of low volatility were formulated with water in such a ratio that the desired rate of use was obtained when the mixture

Fig. 1.—Rotary tiller used to apply soil treatments of low volatility materials to locust beds. Note tank and pump assembly mounted by the side of the tractor motor.

was applied at 100 gallons per acre. Thus, if a liquid material such as Vapam was to be applied at 50 gallons per acre it was diluted with an equal volume of water and the mixture then applied at 100 gallons per acre. With the type of equipment shown in Figure 1, the liquid was sprayed on the soil ahead of the cutting blades of the tiller rotor and then mixed immediately with the soil. More volatile materials, such as chloropicrin and various types of nematocides (EDB and D-D), capable of moving rather quickly through the soil, were introduced into the soil back of the shanks of a field cultivator, and the shank openings were closed with a drag or float as shown in Figure 2. The shanks were spaced from 8 to 12 inches apart. A 10-inch spacing was used for making most of the applications to be discussed. Soil treatment chemicals such as Vapam and allyl alcohol, which possess only a slight degree of volatility were applied in bands spaced only 4 inches apart as in Figure 3, but this type of application proved to be much less effective in terms of weed and disease control than when a rotary tiller was used to mix the chemicals more thoroughly with the soil.

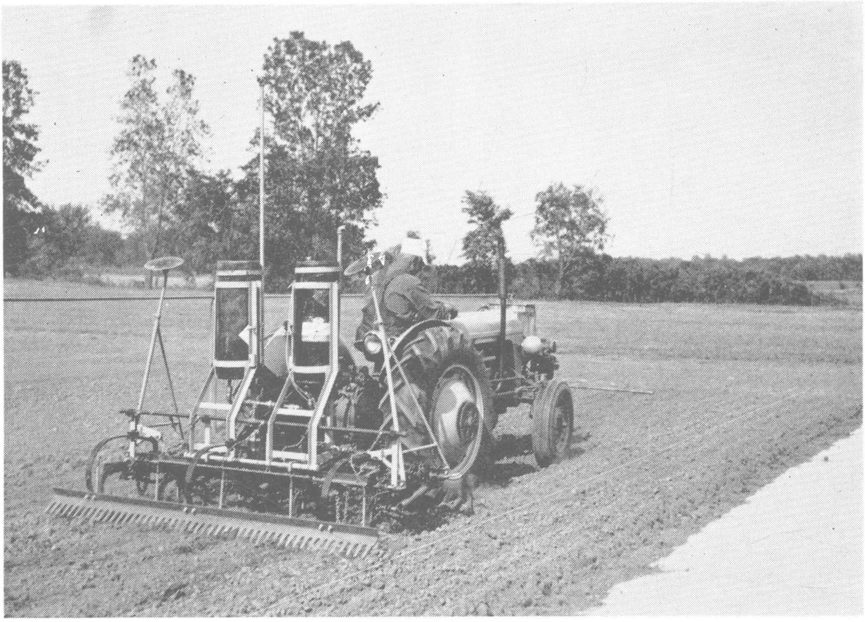

Fig. 2.—Gravity flow applicator used to apply chloropicrin to some of the plots listed in this circular. This was replaced by compressed air equipment similar to that shown in Figure 4 in some of the later experiments.

The field cultivator assembly of Figure 2 was designed primarily for the application of chloropicrin (3). Flow lines from the supply tank to the applicator shanks were fitted with flow regulators calibrated for the desired rate of application. Stoddard solvent was used to indicate the positive flow of fluid to the shanks as they entered the soil. Solvent was then shut off and the chloropicrin valve opened so that very little of the latter material escaped above ground. The application rate maintained only by a low gravity head sometimes varied. For this reason, equipment shown in Figure 4 was assembled so that constant air pressures of 10 to 30 pounds per square inch could be selected and applied to cylinders of chloropicrin and other compounds of medium volatility to secure desired application rates.

Mixtures which contain materials of highly volatile nature such as methyl bromide must be confined within the soil mass for a minimum time interval to be fully effective. A common method of doing this is to cover the treated, or to be treated, soil with an impervious film such as a sheet (roll) of polyethylene, which must, of course, be sealed at the edges by some means, usually a layer of soil. Trizone (a mixture of

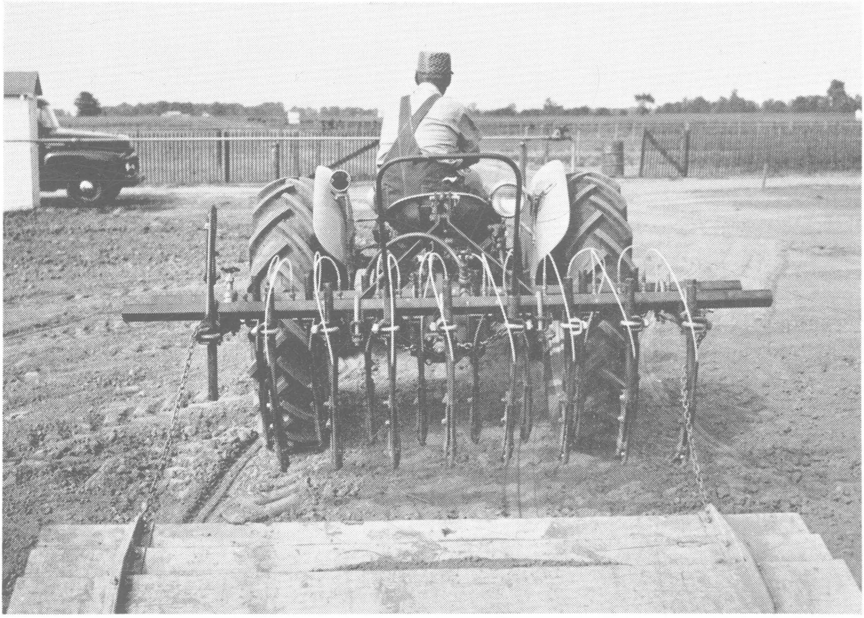

Fig. 3.—A type of field cultivator applicator used to apply Vapam and allyl alcohol at a 4-inch spacing to some of the locust beds treated in 1957. (Treatments 8 and 9 in Table 2). This close shank spacing was not sufficiently effective for further use.

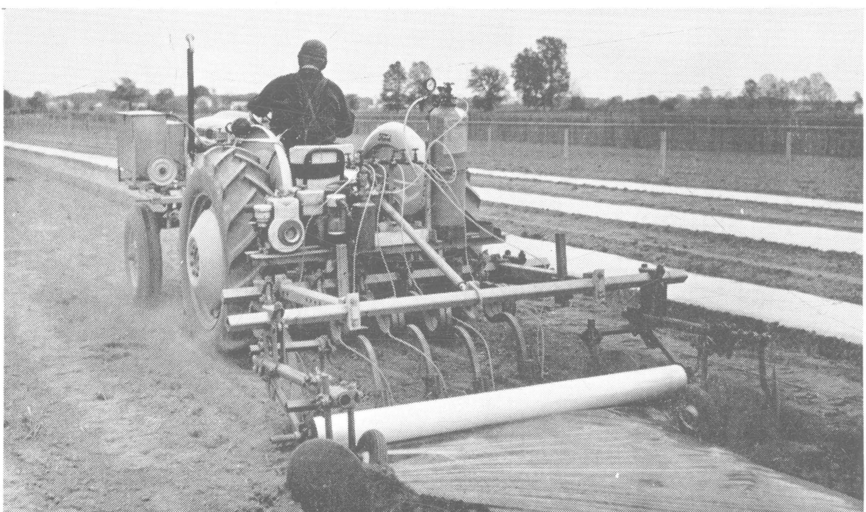

Fig. 4.—Laying a roll of polyethylene film over Brozone being applied by a field tiller with shanks spaced 10 inches apart.

methyl bromide, chloropicrin, and propargyl bromide) and Brozone (a mixture of methly bromide, chloropicrin and petroleum hydrocarbons) are two such formulations that have been used in this series of experiments. The application of these mixtures to the soil and covering them immediately with a film of polyethylene was accomplished by attaching a tarp-laying device directly back of a field-cultivator assembly designed to apply the volatile formulations in the soil at a depth of 6- to 8-inches on 10- to 12-inch centers, as illustrated in Figure 4. Compressed air under a pressure of about 15 pounds per square inch was used in this instance to force the methyl bromide-containing mixture from the containing cylinder and into the soil. The use of air has since been discontinued and the cylinders are pressured with nitrogen gas to eliminate the explosive hazard present when air is in contact with the methyl bromide in a confined space.

The effectiveness of low volatile compounds such a Vapam or allyl alcohol can be increased by delaying their natural rate of escape from the soil after they are applied. This can be accomplished by means of an impermeable or even a partially permeable film (4). Application of some of the treatments used in this series of experiments, was done by attaching the tarp-laying device just back of the rotary tiller that was used for mixing some of the less volatile compounds with the soil, as illustrated in Figure 5. Polyethlene tarp is compartively costly, even in the thinnest grade that can be used, and whether its use with a material such as Vapam can be justified on a cost basis is somewhat questionable. However, the cost factor can sometimes be made less critical since the quantity of fumigant needed to give a certain degree of pest control can be reduced when a tarp cover is used.

An alternative, but somewhat less effective, seal can be obtained by applying enough water to wet the surface of the soil to a depth of one-half to one-inch immediately after treatment with a fumigant. The presence of the water in the surface layer temporarily blocks the interparticle spaces in the soil and thus slows down the escapes of gases from lower down in the soil layer. It also tends to rearrange the soil particles in a more tightly packed mass at the surface and thus leaves fewer surface openings for the escape of gases. Such use of a water seal was introduced into this series of experiments in at least two instances.

RESULTS AND DISCUSSION

The experimental work started in 1956 on a method to increase the stand of locust seedlings and to reduce the cost of caring for the beds in which they were being grown (1) was continued in 1957. The

Fig. 5.—Laying polyethylene tarp over Vapam being applied with a rotary tiller.

inscecticide, dieldrin, was added to Vapam in one instance. Vapam was applied with a rotary tiller at three different rates and Mylone at two rates. Also, Vapam and allyl alcohol were applied at one rate with a field-tiller assembly in which points, or shanks, were placed only 4 inches apart. The results obtained in this experiment are presented in Table 1, which also includes data on the stand of seedlings in a bed treated by nursery personnel (Treatment B).

Vapam gave the best stand of locust seedlings in sandy soil at the 45-gallon per acre rate, indicating that 60 gallons may have been somewhat phytotoxic. However, in the loam soil the 60 gallon rate was definitely superior. Weed control, for some reason which is not apparent, was better at the 45 than at the 60-gallon rate. Adding dieldrin to Vapam (Treatment 5) did not increase the stand of locust seedlings, and possibly decreased the effectiveness of Vapam as a herbicide.

Mylone at 150 pounds per acre gave a better stand of locust in sand than did 200 pounds, but again the reverse was true in the loam soil with a higher rate of application giving better results, as it did with Vapam. The heavier rate of application of Mylone was definitely the more effective in weed control.

TABLE 1.—The effect of various soil treatments on the stand of locust seedlings and on weed populations in nursery beds at Green Springs in 1957. Treated on May 10 and counted on July 31 and August 15. Four 10-foot sections were always counted in each differently treated bed and data as given are averages of these counts in terms of the number of plants per square foot.

Treatments	Rate applied per acre	Average number of locust seedlings per sq. ft. of nursery beds in			Average number of weeds per sq. ft. of bed on	
		Sand	Loam	Average	July 31	August 15
1. None (Check)	——	9.1	12.3	10.7	7.8	3.2
2. Vapam	30 gal.	11.5	18.0	14.8	2.7	2.3
3. Vapam	45 gal.	20.8	18.9	19.8	1.8	1.2
4. Vapam	60 gal.	16.3	24.5	20.4	4.3	3.1
5. Vapam + dieldrin	50 + 2 gal.	11.0	18.4	14.7	4.5	2.8
6. Mylone (W-85)	150 lb.	15.7	17.1	16.4	3.7	3.7
7. Mylone (W-85)	200 lb.	14.0	18.7	16.4	2.2	1.2
8. Vapam[1]	50 gal.	14.9	15.3	15.1	4.0	2.3
9. Allyl alcohol[1]	50 gal.	16.3	17.0	16.6	5.8	2.9
A. None (Check)			8.9			
B. Vapam[2]	50 gal.		19.0			

[1]Treatments 8 and 9 applied with a field cultivator—others with a rotary tiller.

[2]Treated by Nursery Personnel, with accompanying check.

NOTE: The nursery beds used in these experiments were planted at the average rate of 50 to 60 seeds per sq. ft., or about 200 seeds per lineal foot of beds 4 feet wide. Virtually all of the plants listed in the tabular data as given in this and the following tables reached a size satisfactory for planting. Before the use of the Vapam treatment, now generally used, 8 to 11 plants were available for planting per sq. ft. of nursery bed, and this has now been increased to 20 to 30 where Vapam is used as a soil treatment.

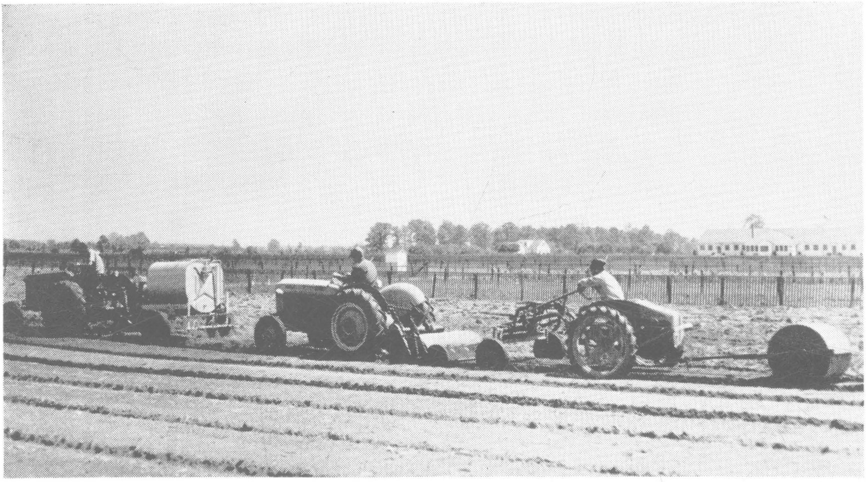

Fig. 6.—Personnel of Green Springs Nursery making Vapam application with sprayer, rotary tiller, and roller in series.

When Vapam and allyl alcohol, two materials which move little through the soil from the point of application, were applied at 50 gallons per acre with the applicator points placed as close together as 4 inches (Figure 3), the increase in stand of seedlings and the control of weeds by Vapam was somewhat inferior to the results obtained when 45 gallons were applied with a rotary tiller (Treatment 8 versus 3). Allyl alcohol was slightly less effective than Vapam in both categories (stand improvement and weed control).

Nursery personnel treated several beds to be planted to locust by applying Vapam with a rotary tiller in the spring of 1957 and succeeded in doubling the stand of seedlings over that in a nearby untreated check bed. In this instance, the Vapam was applied to the soil with a conventional sprayer a few yards ahead of the following rotary tiller (Figure 6) which allowed for a small loss of Vapam by evaporation before it was worked into the soil, but in spite of this, the results in terms of stand improvement and weed control were very satisfactory.

In 1958, several experiments designed to study the effect of such factors as the depth of application, rate of application, the use of a polyethylene cover, the method of application, variations in the formulation, etc., on the stand of seedlings, and on weed control in locust beds, were carried out. In one experiment the comparative effectiveness of Vapam and of Mylone applied at different depths and at different rates per acre was observed. The data obtained are shown in Table 2.

When Vapam applied at 50 gallons per acre was mixed with the soil to a depth of 6 inches, it was slightly less effective in improving the stand of locust and in controlling weeds, than when the same amount was worked into only the top 3 inches of soil. This possibly was to be expected, since the concentration of the Vapam was twice as great per unit of soil volume in the 3-inch as in 6-inch layer of soil. When the concentration in the 3-inch layer was halved by applying only 25 gallons of Vapam per acre (Treatment 3), the degree of weed control and the stand of locust seedlings were both much less, even less than when 50 gallons per acre wes applied to a depth of 6 inches. When the application of Mylone was varied in the same manner, the results were somewhat different, in that the stand of seedlings was as good (actually better) when the rate of application was halved at the 3-inch depth, although weed control was not as good. The addition of Nemagon to Vapam (Treatment 4) added little or nothing to the performance of Vapam used alone (Treatment 1), with a slight decrease in the stand of seedlings and a slight increase in weed control.

In another experiment (Table 3), Vapam was applied with a rotary tiller to two different beds, after which one of them was covered with a polyethylene tarp for a period of 2 days after treatment. The use of the tarp improved the effectiveness of the Vapam, as shown by the fact that the seedling population per unit of bed area was increased and the number of weeds was decreased. When the Vapam was drenched into the soil, there was some weed control one month after planting (July 15) but none about 4 weeks later (August 11), and the stand of locust seedlings was less than that in the untreated check bed. Where Picfume (chloropicrin) was used the water seal was at least the equal of the tarp cover in controlling weeds, and it gave a somewhat higher population of locust seedlings.

In a third experiment (Table 4) methyl bromide (MC-2) was used to treat the soil of the nursery beds. In one instance the methyl bromide was introduced under a previously laid polyethylene tarp at 50-foot intervals, and in treating an adjacent bed, it was vaporized from a hose trailing at a distance of about 12 feet behind the point where the tarp was being placed on the soil by a tarp-laying device attached to the rear of a tractor which carried the supply of methyl bromide. Weed control was approximately the same with the two methods of application, but the continuous application from the trailing hose gave a considerably better stand of locust seedlings than did the intermittent spacing of the fumigant.

An increase in the rate of application from 0.50 pound per 100 square feet of bed area used in Treatment 2 to 0.75 pound (Treatment 3) and to 1.0 pound in Treatment 5 added nothing to the results obtained when only 0.50 pound was applied by the trailing hose method of Treatment 2. Neither did an increase to 1.0 pound per 100 square feet, applied at 50-foot intervals (Treatment 4), add anything to the results obtained with the 0.5 pound used in Treatment 1 where the same method of application was used. Weed control was excellent in all of the treatments where methyl bromide was used.

In another experiment in 1958 Mylone, which had been mixed with bran in a 50 percent formulation for convenience in application, was incorporated into the soil of the nursery bed to a depth of 6 to 8 inches by a rotary tiller. In one bed the bran-Mylone mixture was mixed with soil with no further treatment, and in another instance a treated bed was drenched lightly with one--fourth inch of water applied from an overhead irrigation system. In a third treated bed the rate of water application was increased to one inch, and in a fourth bed the bran-Mylone mixture was spread over the surface of the soil and one inch of water was added without previous tilling. The data obtained on seedling stand and weed control with these four types of application are shown in Table 5 in Treatments 1, 2, 3, and 4, respectively.

All treatments gave some increase in the stand of locust seedlings, with the heavily drenched bed showing the best stand. Drenching the soil added nothing to the degree of weed control obtained, but there were fewer weeds in all three of the tilled beds. Weed control was poor with Treatment 4 where the Mylone was not mechanically mixed with the soil. This was also true when Vapam and Nemagon were applied by drenching them into the soil, as indicated in Treatments 5 and 6, respectively. Thus, these data indicate that a soil fungicide such as Mylone is more effective in its action when it is mechanically mixed with the soil than when it is carried downward in the soil mass with water only.

The experiments relative to the influence of various treatments on the stand of locust seedlings and the accompanying weed populations were continued in 1959, three of them being located at Green Springs and one at the Zanesville Nursery. In one of the experiments at Green Springs, Vapam and Mylone were used alone. Vapam was also applied with Eptam and Endothal, two herbicides of comparatively recent introduction, in a check on the possibility that the herbicidal effect of Vapam might be increased. These herbicides were also used alone in a compar-

TABLE 2.—Comparative performance of Vapam and Mylone when applied at different rates and at different depths in the improvement of the stand of locust seedlings, and in weed control at Green Springs in 1958. All treatments applied with a rotary tiller.

Treatments	Rate applied per acre	Depth of treatment in inches	Number of locust seedlings per sq. ft. of bed	Number of weeds per sq. ft. of bed on July 15	Number of weeds per sq. ft. of bed on August 11
1. Vapam	50 gal.	6	21.0	8.6	1.8
2. Vapam	50 gal.	3	22.3	5.9	2.1
3. Vapam	25 gal.	3	14.8	31.3	4.5
4. Vapam + Nemagon (EC-2)	50 + 6 gal.	6	18.8	7.1	2.0
5. None (Check)	——	6	8.3	45.6	4.1
6. Nemagon (EC-2)	6 gal.	6	9.0	17.0	1.9
7. Mylone W-85	200 lb.	6	15.5	2.8	1.7
8. Mylone W-85	200 lb.	3	21.8	6.4	4.5
9. Mylone W-85	100 lb.	3	27.8	23.5	4.1

TABLE 3.—Comparative effect of a water seal and a polyethylene tarp (cover) on Vapam and Picfume as treatments for locust beds at the Green Springs Nursery in 1958.

Treatments	Rate applied per acre	Method of application	Number of locust seedlings sq. ft of bed	Number of weeds per sq. ft. of bed on July 15	Number of weeds per sq. ft. of bed on August 11
1. Vapam	50 gal.	Rototilled and Tarped	28.5	4.1	1.0
2. Vapam	50 gal.	Rototilled only	21.0	8.6	1.8
3. Vapam	50 gal.	Drenched into Soil	20.3	11.6	17.3
4. Picfume	35 gal.	Field Tiller Water Sealed	25.8	1.6	0.7
5. Picfume	35 gal.	Field Tiller Tarped	23.5	1.6	1.2
6. None	——		22.0	33.9	4.5

TABLE 4.—Comparative effect on stand of locust seedlings and on weed control when methyl bromide (MC-2) was applied at different rates and in interrupted and continuous streams under a polyethylene tarp.

Treatments	Pounds applied per 100 sq. ft	Locust seedlings per sq. ft. of bed	Weeds per sq. ft. of bed on	
			July 15	August 11
1. MC-2 applied every 50 ft. under tarp	0.50	23.8	0.4	1.4
2. Vaporized from a trailing hose during tarp application	0.50	30.8	0.4	0.8
3. As in No. 2	0.75	27.5	0.5	0.3
4. As in No. 1	1.00	22.8	1.3	0.5
5. As in No. 2	1.00	23.3	1.2	0.6
6. None (Check)	—	21.3	53.9	3.3

TABLE 5.—The effect of a water drench on the performance of Mylone when applied as a preplant treatment to locust beds at Green Springs in 1958.

Treatments	Rate applied per acre	Locust seedlings per sq. ft. of bed	Weeds per sq. ft. of bed on	
			July 15	August 11
1. Mylone—50% in bran Rotary tiller only	400 lb.	21.4	2.0	4.5
2. Mylone—50% in bran Tilled and drenched lightly	400 lb.	21.4	2.5	3.9
3. Mylone—50% in bran Tilled and drenched	400 lb.	20.7	2.2	6.9
4. Mylone—50% in bran drenched only	400 lb.	21.4	9.6	10.7
5. Vapam—drenched only	50 gal.	16.2	11.6	17.3
6. Nemagon (EC-2)—drenched	6 gal.	18.6	10.4	13.2
7. None (Check)	—	12.8	12.9	16.9

ison of their weed-controlling effectiveness in this type of application. Eptam was also applied with Fumazone and with EDB in a further test of the possible effect of nematocidal compounds on the growth of the locust seedlings. The results obtained are given in Table 6.

Vapam gave slightly better weed control than did Mylone in this experiment, and essentially the same stand of seedlings. The addition of Eptam to Vapam had little effect on weed control over Vapam alone and the stand of seedlings was reduced. When Endothal was added to Vapam, weed control was reduced, but the best stand of seedlings of the experiment resulted. Eptam used alone gave good weed control and a good stand of seedlings. Endothal did less well in both categories. Eptam gave good weed control with Fumazone, but was less effective with EDB, and the stand of seedlings was reduced below the untreated check with both nematocides. The use of a polyethylene tarp with Vapam and Mylone had little effect on the performance of the two fungicide-herbicide compounds in this instance.

In another experiment performed in 1959, the effect of mixing Vapam and Mylone with the soil in both 4- and 8-inch layers was investigated, as was the effect of adding a water seal to the soil immediately after the chemicals were added. The results obtained are indicated in Table 7.

When 50 gallons per acre of Vapam was mixed with the soil of the nursery bed to a depth of 4 and of 8 inches (Treatments 2 and 4), the improvement in seedling stand and in weed control were both better with the more shallow application, indicating that the greater concentration of Vapam per unit of soil volume was beneficial. When the concentration of Vapam was held the same in the 4- and 8-inch soil layers by adding only 25 gallons per acre in a 4-inch layer (Treatments 3 and 4), weed control was better when the 8-inch layer was treated, and the seedling stand was greater when a water seal was added, but was the same with the two depths of treatment when no water was added. The results were somewhat different with Mylone, since the 4-inch treatment with 200 pounds per acre was no better than that of 8 inches in dry soil, but was somewhat better with a water seal. Also, the use of only 100 pounds gave better results, especially in weed control, in a 4-inch layer than did the addition of twice as much chemical, a result that is difficult to explain.

An averaging of the data for all treatments in the experiment (last line of Table 7) indicates that the use of a water seal to slow down the escape from the soil of the different chemicals used had an unfavorable effect on weed control, but did increase the number of locust seedlings.

TABLE 6.—Effect of various herbicides when used alone and in combination with soil fungicides and nematocides on the stand of locust seedlings, and on weed control at Green Springs in 1959. Treated on May 27 and counted on July 9 and August 5.

Treatments	Rate applied per acre	Average number of locust seedlings per sq. ft. of bed	Average number of weeds per sq. ft. of bed on July 9	Average number of weeds per sq. ft. of bed on August 5
1. None (Check)	——	19.5	14.1	0.8
2. Eptam	1 gal.	26.0	0.5	0.2
3. Endothal	3 gal.	18.8	8.6	2.0
4. Fumazone + Eptam	6 + 1 gal.	8.3	0.3	0.4
5. Vapam	50 gal.	26.6	0.4	0.1
6. EDB + Eptam	50 + 1 gal.	10.3	8.2	0.7
7. Mylone	200 lb.	26.1	0.6	0.5
8. Vapam + Eptam	50 + 1 gal.	16.7	0.3	0.4
9. Vapam + Endothal	50 + 3 gal.	28.7	5.1	0.5
10. Vapam (Tarped)	50 gal.	24.8	0.1	0.1
11. Mylone (Tarped)	200 lb.	22.1	0.9	0.5

Soil Temperature 72°F, Air Temperature 82°F, Soil Moisture about optimum.

TABLE 7.—The influence of a water seal on the effect of various soil-treatment chemicals on the stand of locust seedlings and weeds at Green Springs in 1959. Treated on May 27 and counted on July 9.

Treatment	Rate applied per acre	Depth of application in inches	Average number of locust seedlings per sq. ft. of bed		Average number of weeds per sq. ft. of bed	
			No seal	Water seal	No seal	Water seal
1. None (Check)	——	4	21.2	22.0	13.4	13.8
2. Vapam	50 gal.	4	23.5	25.8	5.6	6.7
3. Vapam	25 gal.	4	22.0	25.3	8.0	8.3
4. Vapam	50 gal.	8	21.9	28.7	3.1	4.0
5. Mylone (W-85)	200 lb.	8	19.1	17.3	2.9	4.9
6. Mylone (W-85)	200 lb.	4	17.5	19.1	3.4	4.1
7. Mylone (W-85)	100 lb.	4	17.1	20.2	0.8	1.5
8. Fumazone + Endothal	6 + 3 gal	4	19.7	21.1	3.3	4.3
9. EDB + Endothal	8 + 3 gal.	4	19.0	20.7	6.6	5.3
Averages			20.1	22.3	4.2	4.9

Soil Temperature 72°F, Air Temperature 82°F.

The results relative to the effect of mixing Vapam and Mylone with the soil at different depths were inconclusive in this instance.

In a third experiment at Green Springs in 1959 various formulations of methyl bromide (MC-2) were applied at different rates per acre in an effort to determine the best quantities to use in treating nursery beds located on the sandy loam type of soil present in that nursery. The applications were made with a field cultivator type of applicator, similar to that shown in Figure 4, with a tarp-laying attachment which placed a film of polyethylene over the treated bed before the methyl bromide formulations could escape into the atmosphere. The applicator shanks were placed 10 inches apart and the chemicals were injected into the soil at a depth of 8 to 10 inches. The results obtained are shown in Table 8.

All treatments gave comparatively good weed control and the stand of locust seedlings was increased over that present in the untreated check beds. Methyl bromide (Treatments 1 and 2) gave better weed control when used at the higher rate but the stand of seedlings was less, possibly indicating a slight phytotoxic action of the chemical on the very young plants. When Trizone (methyl bromide + chloropicrin + propargyl bromide) was applied at three different rates, the seedling population was increased slightly as the rate became greater, but the control of weeds with an increase in the use of Trizone was less definitive. Variations in the rate at which Brozone (methyl bromide + chloropicrin + petroleum hydrocarbons) was applied seemed to have very little effect on seedling stand, with the number of plants per unit of bed area being somewhat less than it was with methyl bromide only, or with Trizone. Weed control, on the other hand, was perhaps best with Brozone, but it too was altered but little by increasing the rate per acre at which the Brozone was applied.

A fourth experiment on the treating of locust beds was performed at the Zanesville State Nursery* in the spring and summer of 1956. Vapam was applied at a depth of 3 and 6 inches and one of the two beds treated to a depth of 6 inches was covered with a polyethylene tarp. Mylone was both tarped and left uncovered. EDB and Nemagon were used with Vapam in two beds each, and one of each of these was covered with polyethylene tarp. Eptam and Endothal (two herbicides) were each used at three different rates. The data relative to this experiment are given in Table 9.

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*Mr. W F. Wood is superintendent of this nursery and the authors ore indebted to him for this experiment.

TABLE 8.—The effect of different formulations of methyl bromide on the stand of locust seedlings and on weed control at Green Springs in 1959. Treated May 27 and counted on July 9 and August 5.

Treatments	Rate applied per acre	Average number of locust seedlings per sq. ft. of bed	Average number of weeds per sq. ft. of bed on; July 9	August 5
1. Methyl bromide	218 lb.	25.7	1.8	0.1
2. Methyl bromide	435 lb.	22.5	0.7	0.3
3. Trizone	140 lb.	26.4	1.3	0.8
4. Trizone	200 lb.	27.3	1.0	0.3
5. Trizone	260 lb.	28.8	3.4	0.9
6. Brozone	115 lb.	22.5	0.6	0.1
7. Brozone	210 lb.	21.4	1.3	0.7
8. Brozone	320 lb.	22.5	0.5	0.2
9. None (Check)	——	19.5	14.1	0.8

Soil Temperature 72°F, Air Temperature 82°F.

TABLE 9.—The effect of various soil-treatment chemicals on the stand of locust seedlings and on weed control at Zanesville in 1959. Treated on June 10 and counted on July 17.

Treatments	Rate applied per acre	Tarped Yes or No	Average number of locust seedlings per sq. ft. of bed	Average number of weeds per sq. ft. of bed
1. Vapam, 6 in. depth	50 gal.	Yes	29.2	0.1
2. Vapam, 6 in. depth	50 gal.	No	29.0	1.3
3. Vapam, 3 in. depth	50 gal.	No	26.6	1.3
4. Mylone	200 lb.	Yes	25.8	0.2
5. Mylone	200 lb.	No	27.0	0.9
6. EDB (M-731) + Vapam	12 + 50 gal.	Yes	28.5	0.2
7. EDB (M-731) + Vapam	12 + 50 gal.	No	26.9	0.2
8. Nemagon (EC-2) + Vapam	6 + 50 gal.	Yes	29.1	0.2
9. Nemagon (EC-2) + Vapam	6 + 50 gal.	No	31.5	0.2
10. Eptam	4 qt.	No	29.2	0.3
11. Eptam	3 qt.	No	29.0	0.1
12. Eptam	2 qt.	No	25.5	0.1
13. Endothal	4 gal.	No	25.6	1.1
14. Endothal	3 gal.	No	26.7	0.7
15. Endothal	2 gal.	No	27.7	0.9
16. None (Check)	—	—	24.8	3.5

Soil Temperature = 80°F, Air Temperature = 90°F, Soil Moisture = Optimum minus.

The stand of locust seedlings was unusally good in the untreated check beds and the weed population was also lower than usual in untreated soil. However, all treatment gave some control of weeds, with very few being present in some of the treatments. All treatments gave some, but often slight, increase in seedling stands; which did not happen when nematocides were used at Green Springs.

In this experiment Vapam applied at 50 gallons per acre and covered with a tarp gave better weed control and a higher population of seedlings than when left uncovered, or when the same 50 gallons per acre was mixed with the soil to depth of 3 instead of 6 inches. Mylone was less improved in its performance when tarped, since the stand of seedlings was not increased above that in the bed not covered, although there was a slight increase in weed control. When EDB was added to Vapam both weed control and the stand of seedlings remained about the same as with Vapam used alone, indicating that the EDB was not injurious in this instance. The tarped plot was slightly better than its uncovered counterpart. When Nemagon was added to Vapam the resulting locust stand was the best of the experiment and weed control was good also.

Eptam gave excellent weed control and a good stand of seedlings. Endothal was less effective in weed control than Eptam and the average seedling stand was somewhat less.

In an average of all tarped plots versus the plots that were not, those that were covered showed an average seedling stand of 28.0 per square foot of plant bed, whereas there were 28.6 in the beds that were not tarped; certainly not a significant difference. The respective weed populations were 0.18 and 0.63 per square foot of nursery bed. This indicates that the use of a tarp did not serve to increase the stand of locust plants in this experiment, but that it did improve the herbicidal action of Vapam and Mylone to a slight extent.

In 1960, six different chemical compounds were applied to nursery beds to be planted to locust. Vapam was applied at three different rates, by two different methods, and at three different depths; also, three of the treatments included a tarp cover. Mylone was applied at two rates and one of the three treatments included a cover. Trapex was applied at two rates and two depths, with one treatment covered with a polyethylene tarp. Brozone and Trizone were each used at two rates of application, as was Picfume. Dexon, a soil fungicide, was added to one bed as a check on what it might do to improve the stand of seedlings. The data obtained in this list of 24 treated beds and two untreated check plots are given in Table 10.

TABLE 10.—Comparative effect of various soil treatments, applied at different depths, and with and without the use of a tarp cover, on the stand of locust seedlings obtained, and the control of weeds in nursery beds, at Green Springs in 1960.

Treatments	Rate applied per acre	Tarped or not	Applied with rotary tiller (R) or field cultivator (C)	Depth of treatments in inches	Average number of locust seedlings per sq. ft. of bed	Average number of weeds per sq. ft. of bed: July 8	Average number of weeds per sq. ft. of bed: August 4
1. Mylone (WP-85)	170 lb.	—	R	6	25.9	1.75	7.03
2. Mylone (WP-85)	170 lb.	Yes	R	6	27.8	0.50	1.53
3. Mylone (WP-85)	250 lb.	—	R	6	21.8	6.58	6.33
4. Vapam	33 gal.	—	R	3	18.0	1.10	1.08
5. Vapam	33 gal.	—	R	6	16.6	2.53	2.28
6. Vapam	33 gal.	Yes	R	6	23.5	0.48	4.00
7. Vapam	33 gal.	Yes	C	6	20.9	5.40	2.63
8. Vapam	50 gal.	—	R	3	19.5	4.13	0.19
9. Vapam	50 gal.	—	R	6	20.5	3.40	1.50
10. Vapam	50 gal.	Yes	R	6	26.1	2.38	1.13
11. Vapam	67 gal.	—	R	3	20.2	0.73	2.15
12. Vapam	67 gal.	—	R	6	17.2	0.40	1.05
13. Trapex	33 gal.	—	R	3	18.7	2.15	1.30
14. Trapex	33 gal.	—	R	6	14.4	7.38	2.00
15. Trapex	33 gal.	Yes	R	6	20.5	3.20	1.75
16. Trapex	50 gal.	—	R	3	19.5	1.50	2.45
17. Trapex	50 gal.	—	R	6	16.1	9.15	7.38
18. Brozone	300 lb.	Yes	C	8	24.2	0.13	0.30
19. Brozone	400 lb.	Yes	C	8	20.7	0.12	0.33
20. Trizone	200 lb.	Yes	C	8	20.3	0.12	0.33
21. Trizone	300 lb.	Yes	C	8	24.3	0.15	0.15
22. Picfume	25 gal.	Yes	C	8	27.9	2.88	9.50
23. Picfume	35 gal.	Yes	C	8	25.1	0.95	1.70
24. Dexon (50%)	50 lb.	—	R	4	24.8	1.91	6.63
25. None (Check)	——		R	6	20.9	2.00	3.38
26. None (Check)	——		R	6	18.2	18.9	2.63
Average 4 plots tarped (2, 6, 10, 15)					24.4	1.6	1.5
Average 4 plots not tarped (1, 5, 9, 14)					19.4	3.8	3.2

The use of a polyethylene tarp with 170 pounds of Mylone per acre brought about some increase in the stand of seedlings and a very definite increase in the degree of weed control. A similar effect is illustrated in Figure 7, where the bed on the right was treated with Vapam at 50 gallons per acre and covered with a tarp, whereas the bed on the left was an untreated check. The appearance of these same beds 8 weeks later is shown in Figure 8. The same result was evident when Vapam at 33 gallons per acre was covered with a tarp (Treatment 5 versus 6). When a tarp was applied to 33 gallons per acre of Trapex there was again a definite increase in the stand of seedlings and in weed control. When these four comparisons of no tarp versus tarped plots are averaged (last two lines of Table 10) there was an increase in seedling stand of 26 percent and a decrease in weed numbers of 56 percent.

Increasing the quantity of Mylone from 170 to 250 pounds per acre resulted in a decrease of seedling stand. When Vapam was used at 33, 50, and 67 gallons per acre, 50 gallons gave the best stand of seedlings. The use of 67 gallons meant little in terms of seedling population, but there was a definite increase in weed control. Trapex at 50 gallons was no better than when used at 33 gallons. Brozone and Trizone showed little response to an increase in the rate of use, but chloropicrin at 35 gallons per acre was definitely more effective, especially in weed control, than it was at 25 gallons. Dexon at 25 pounds of the active ingredient per acre gave a good seedling stand, but since it is not a herbicide, it gave no weed control.

When Vapam was applied by a field cultivator with the shanks spaced 10 inches apart, it was less effective in increasing the stand of seedlings and in controlling weeds than when it was mixed with the soil by rotary tiller (Treatment 8 versus 7). Vapam, at 33 gallons per acre, was more effective in this experiment when it was mixed with the soil to a depth of only 3 inches than at 6 inches (Treatment 4 versus 5). At 50 gallons per acre the 6-inch application was slightly more effective than that made at 3 inches, but at 67 gallons there was a decrease in seedling stand at 6 inches compared with 3 inches. Weed control was slightly better at 6 than at 3 inches. When Trapex was applied at 33 and 50 gallons per acre the results were better in both seedling stand and in weed control when it was mixed to a depth of 3 inches than at 6 inches. When all five comparisons at the two depths are averaged both seedling stand and weed control were better at the more shallow depth of application.

Thus, in this experiment the use of a polythylene tarp to hold such low volatility fungicides as Vapam, Mylone, and Trapex in the soil

Fig. 7.—Comparative weed populations in locust beds where the one on the right was treated with Vapam and then covered with a polyethylene tarp and the one on the left was an untreated check. Represented by treatments 6 and 26, respectively, in Table 10.

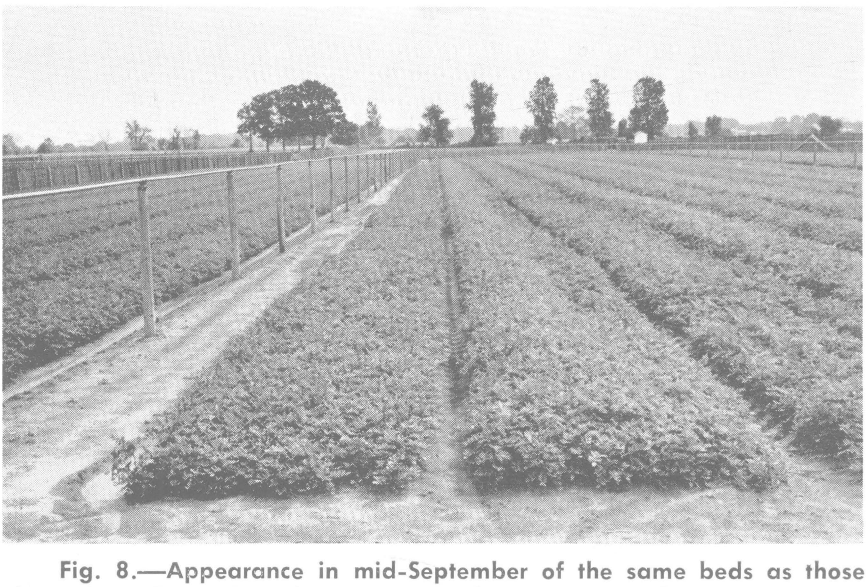

Fig. 8.—Appearance in mid-September of the same beds as those pictured in Figure 7. This illustrates the rapid growth of these locust seedlings in a period of about 8 weeks and indicates that most of them were of plantable size before the end of their growth period in the fall.

over a longer period than they would remain there with no cover, considerably increased their effectiveness in bringing about an increase in the seedling stand of lccust and in decreasing the weed population in the treated beds. Any increase in performance of Mylone, Vapam, Trapex, Brozone, and Trizone that may have resulted from an increase in the rate of application was only minor in nature, but chloropicrin was definitely more effective at 35 than at 25 gallons per acre. Vapam was more effective when mixed thoroughly with the soil with a rotary tiller than when applied on 10-inch centers with a field cultivator type of applicator. There was some evidence that mixing Mylone, Vapam, and Trapex to a depth of only 3 inches was more effective in stand improvement and weed control than mixing them to a depth of 6-inches, although the differences was less clear-cut with Vapam than with Mylone and/or Trapex.

In 1961, the last year of this experimental series, methyl bromide in two formulations (Brozone and Trizone) was again included in the list of treatments, as were Vapam and allyl alcohol at different rates of application, and a new herbicide (Tillam) was used alone and as a supplement to Vapam and allyl alcohol in mixtures designed to give a maximum of weed control. Also Vapam and allyl alcohol, used in the minimum dosage, were covered with a polyethylene tarp (Figure 5) to determine the effect of its use on the comparative performance of the two compounds. The data obtained on stand increase in treated plots over that present in the untreated check beds, and in weed control, are presented in Table 11.

The best average stand of seedlings was obtained with Vapam, and the best of the experiment was present in the bed treated with only 30 gallons per acre and then covered with a polyethylene tarp (Treatment 11) immediately after the chemical was rototilled into the soil. The use of a tarp cover also gave good results with allyl alcohol. In Treatment 15 where 40 gallons per acre was tarped it gave better results in both seedling stand and weed control than did 80 gallons in Treatment 18 without a tarp cover. When the data on seedling stand and weed control were averaged (last two lines of Table 11) the locust population was three plants per foot of bed higher where a tarp cover was applied and there were fewer weeds.

The best weed control of the experiment was obtained with Brozone and Trizone, with the lower rates of application used doing nearly as well as the higher ones. However, the stand of locust seedlings was not quite as high as with Vapam and allyl alcohol. Tillam at one

TABLE 11.—Effect of various soil treatments on the stand of locust seedlings and on weed populations in nursery beds at Green Springs in 1961.

Treatments	Rate applied per acre	Tarped with polyethylene	Locust plants per sq. ft. of bed on July 18	Weeds per sq. ft. of bed on July 18	Weeds per sq. ft. of bed on August 10
1. None	——	—	19.5	1.83	2.50
2. None	——	—	19.0	1.58	1.65
3. Tillam	2/3 gal.	—	18.7	0.55	0.88
4. Tillam	1 gal.	—	18.4	0.33	0.43
5. Tillam + Vapam	1 + 30 gal.	—	14.1	0.55	0.23
6. Tillam + allyl alcohol	1 + 40 gal.	—	23.3	0.08	0.28
7. Brozone	300 lb.	Yes	22.1	0.05	0.28
8. Brozone	400 lb.	Yes	22.5	0.00	0.08
9. Trizone	200 lb.	Yes	24.3	0.05	0.25
10. Trizone	300 lb.	Yes	20.6	0.03	0.23
11. Vapam	30 gal.	Yes	29.6	0.20	0.10
12. Vapam	30 gal.	—	25.7	0.83	0.65
13. Vapam	50 gal.	—	21.4	0.70	0.68
14. Vapam	70 gal.	—	25.3	0.58	0.53
15. Allyl alcohol	40 gal.	Yes	26.0	0.35	0.40
16. Allyl alcohol	40 gal.	—	24.4	1.58	0.95
17. Allyl alcohol	60 gal.	—	21.7	0.55	0.55
18. Allyl alcohol	80 gal.	—	24.4	0.45	0.63
AVERAGES: Vapam and allyl alcohol—Tarped			27.8	0.30	0.25
Vapam and allyl alcohol—Not tarped			25.0	1.25	0.80

Treated May 31. Air Temperature = 72°F, Soil Temperature = 70°F, Soil Moisture = Optimum.

gallon (6 pound) per acre gave very good weed control (Treatment 4) but there were fewer locust seedlings than in the untreated check beds. Tillam added to Vapam was less effective than Vapam used alone, which indicates some degree of incompatibility between the two materials. Allyl alcohol plus Tillam gave good weed control and a much better stand of seedlings than was present in the bed treated with Vapam plus Tillam.

The data obtained in this 1961 experiment indicate that it may be possible to halve the application rate of Vapam and allyl alcohol without a loss of effectiveness in weed control and in stand improvement if the treated bed is covered immediately with a polyethylene tarp. The tarp should remain on the bed for a period of at least 24 hours, and possibly for 48 hours. Also, methyl bromide may be expected to give excellent weed control and a worthwhile increase in the stand of locust seedlings. Tillam gave good weed control, but it may bring about a decrease in seedling stand below that in untreated beds. Also, it would appear to be somewhat incompatible with Vapam, but seemed to be more compatible with allyl alcohol.

SUMMARY

Experiments initiated in the mid-1950's at the Green Springs Nursery of the Division of Forestry of the Ohio Department of Conservation showed that the stand of locust seedlings could be considerably increased when the beds in which they were to be grown were treated with certain soil fungicides. Also, if the compounds used possessed some degree of herbicidal action the cost of weeding the beds could be greatly reduced.

In 1956, the incorporation of Vapam and Mylone into the soil of beds later planted to locust increased the number of seedlings over that in untreated soil by 200 to 300 percent and the number of weeds present was greatly reduced in the treated beds.

Ethylene dibromide (EDB), a nematocide, proved to be somewhat phytotoxic to the locust seedlings and their number was reduced below those in the check plot, both when used alone and with Vapam. Dieldrin, an insecticide also reduced the stand of seedlings. Later it was found that neither nematodes nor insects were important factors affecting the stand of locust seedlings at Green Springs, and their use as soil treatments in these experiments was largely discontinued.

In 1957, it was found that an application rate of 45 to 50 gallons of Vapam was perhaps close to the quantity necessary to give optimum results in increasing the stand of locust seedlings and in decreasing weed population. Mixing the Vapam thoroughly in the top 6 inches

of soil with a rotary tiller was found to give better results than its application with a field cultivator, even with the injection points set as close as 4 inches apart.

Experiments conducted in 1958 indicated that the mixing of 50 gallons of Vapam or of 200 pounds of Mylone (W-85) per acre with the top 3 inches of soil gave slightly better results than if the same quantities were incorporated to a depth of 6 inches, but if only half as much of either chemical was mixed in the first 3 inches, then the results were less satisfactory than when the full amounts were mixed to a depth of 6 inches.

In another 1958 experiment, it was found that covering the bed with a polyethylene film (tarp) immediately after it had been treated with Vapam increased the effectiveness of the chemical to a very considerable degree, both by increasing the stand of seedlings and in weed control. Also, mixing the chemical with soil by mechanical means was found to be more effective than drenching it with water.

Methyl bromide gave very good weed control and a fair increase in seedling stand in another experiment, with some indication that it should be effective in a sandy soil at as little as 0.50 pound per 100 square feet. It was more effective when fed continuously from a hose outlet trailing 15 feet behind and under the tarp-laying device than when introduced at 50-foot intervals along a previously laid tarp.

When Mylone formulated on bran was applied with a rotary tiller at 200 pounds per acre of the active ingredients, it was found to be most effective when drenched heavily with water immediately after application.

Data obtained in 1959 indicated that the effectiveness of Vapam and Mylone in increasing the stand of locust seedlings, and in controlling weeds in the nursery bed, is not appreciably affected by the addition of other herbicides. Also, it was further demonstrated that the use of such nematocides as EDB and DBCP adds nothing to the production of locust seedlings.

In a further test of the comparative effectiveness of Vapam and Mylone in shallow and deep application with a rotary tiller, 50 gallons per acre of Vapam gave approximately equal results when mixed with the soil to depths of 4 and 8 inches, and was less effective when 25 gallons were mixed to a depth of 4 inches than when 50 gallons were applied in an 8-inch layer of soil. The results with Mylone were essentially the same.

When Brozone and Trizone were applied at three different rates, Trizone gave approximately the same stand of seedlings at rates of 140, 200, and 260 pounds per acre, with weed control best in a single trial at 200 pounds. Brozone at 115, 210, and 320 pounds per acre gave much the same stand of seedlings at all three rates, with weed control being slightly the best at the highest rate of use. Brozone was more effective in weed control than Trizone, but the reverse was true with respect to the number of locust seedlings.

In an experiment conducted at the Zanesville Nursery in 1959, the use of a polyethylene tarp with Vapam and Mylone improved the control of weeds over that in beds that were not covered, but had little effect on the stand of seedlings. When 50 gallons per acre of Vapam were applied in 3- and 6-inch soil layers the results in terms of both seedling number and weed control were very similar. Eptam gave much better weed control than did Enthodal.

In 1960, the use of a polyethylene tarp with Mylone, Vapam, and Trapex improved the performance of all three, giving an average seedling stand increase over no cover of 26 percent and an increase in the degree of weed control of 44 percent. Vapam applied with a field cultivator applicator was again less effective than when mixed with the soil by a rotary tiller. Chloropicrin was considerably more effective in both performance categories when applied at 35 than at 25 gallons per acre. Dexon, a soil fungicide, gave a good increase in seedling stand over the untreated check, but gave no weed control. Brozone and Trizone again gave excellent weed control and a fair increase in seedling numbers.

Tillam, a herbicide of recent introduction was used as a supplement with Vapam and allyl alcohol in 1961. It gave good weed control when used by itself and with allyl alcohol. However, it seemed to be somewhat incompatible with Vapam, and as a result weed control was poor when it was added to Vapam. Further the stand of seedlings was less than in the untreated check plots. The use of a polyethylene tarp with Vapam and allyl alcohol again definitely improved the performance of both compounds. Vapam used 30 gallons per acre and tarped gave as good results at 50 and 70 gallons not tarped. This was also true of allyl alcohol.

CONCLUSIONS

In an average of five different experiments in this series in which Vapam was used at 50 gallons per acre and mixed with the soil to a depth of 6 inches with a rotary tiller, the stand of locust seedling was increased from 15 per square foot in untreated beds to 22 per square foot, an increase of nearly 50 percent. Weed populations were reduced from an average of 18 per square foot to only 3, a decrease of 80 percent. In view of these results, the use of Sodium N-methyl dithiocarbamate dihydrate (Vapam and/or VPM) applied as a soil treatment to nursery beds about 2 weeks before they are to be planted to locust would seem to be a desirable addition to the cultural techniques involved in growing seedlings of this plant. Related compounds such as Mylone and Trapex might also be used for the same purpose if the proper methods of application were practiced. The fungicidal and herbicidal properties of methyl bromide are well known and it would seem that this compound, in the various formulations in which it is available, may also be expected to give good control of fungi and weeds.

The use of an insecticide, a nematocide and/or a herbicide in addition to the compounds listed in the preceding paragraph seemed to be unnecessary in those instances in which they were included in this series of experiments.

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APPENDIX

Allyl alcohol—C_3H_5OH

Brozone—Methyl bromide 68.6% + chloropicrin 1.4% + petroleum hydrocarbons 30%

Dexon—Dimethylamino benzenediazo sodium sulfonate

Dieldrin—1,2,3,4,10-hexachloro - 6,7 - epoxy,1,4,4a,5,6,7,8,8a octahydro 1,4-endo-5,8-dimethanonaphthalene

EDB—Ethylene dibromide

Endothal—Disodium 3,6-endoxohexahydrophthalate

Eptam—Ethyl di-n-propylthiolcarbamate

Fumazone—1,2-dibromo-3-chloropropane 70%

MC-2—Methyl bromide 98% + 2% chloropicrin

Mylone W-85—3,5-dimethyl-tetrahydro-1,3,5,2H-thiodiazine-2-thione

Nemagon (EC-2)—1,2-dibromo-3 chloropropane 50%

Picfume (chloropicrin)—trichloro-nitromethane

Tillam—Propyl ethyl-n-propylthiolcarbamate

Trizone—Methyl bromide 61% + chloropicrin 31% + propargyl bromide 8%

Trapex—Methyl isothiocyanate 20% in an organic solvent

Vapam and/or VPM—Sodium N-methyl dithiocarbamate dihydrate